IMPLEMENTATION OF EXPERIMENT ABOUT APICAL BUDS PRUNING TO INCREASE AXILLARY BUDS GROWTH OF TAHUN SPINACH (AMARANTUS HYBRIDUS L.) IN HORTICULTURAL COURSES

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ABSTRACT

There are two purposes of this study, first is to evaluate the effects of apical buds pruning to axillary buds growth and the second is to implement this experiment in Horticultural courses. This study was experimental research, and used randomised design method. The sample was grouped into five groups. The first group was conducted without apical buds pruning (J0) served as the control group, second group (J1), third group (J2), fourth group (J3) and the fifth group (J4) were conducted with apical (topping) buds pruning in 3 cm, 6 cm, 9 cm and 12 cm. There were four times experiments. The data analysis is using ANOVA test. The conclusion is there significant difference in some axillary bud in non-apical buds pruned spinach (J0) and apical buds pruned spinach. The analysis then continued by LSD test or BNT test with the most significant difference was between J0 and J3 (3 cm of pruned apical bud), and the highest number of axillary bud was J1 with 66 on average. The result is that the implementation of this experiment in Horticultural courses is able to increase the activity and creativity of students.

KEYWORDS: spinach, apical bud, axillary bud, horticultural.

INTRODUCTION:

Spinach (*Amarantus Hybridus L.)* is an annual plant which has a great adaptation in the various ecosystem. The root system is a taproot with long and rounded root branches that spread in all directions. Generally, the propagation of spinach carried out generatively using seeds. Spinach is classified into 800 species. In society, spinach classification is divided into two types. Those are wild spinach and cultivated spinach. Two types of wild spinach are ground spinach (*Amaranthus blitum L.)* and spiny spinach (*Amaranthus spinosus L*.). Two types of cultivated spinach are (1) white sekul spinach (*Amaranthus tricolour L.)*. Characteristics of useful spinach are reddish stem or whitish green stem, flower in the armpit of the branch. Sekul spinach with the red stem called red spinach, while sekul spinach with the white stem called white spinach. (2) Tahun spinach (*Amaranthus hybridus L*.) which has wide leaves characteristics. Tahun spinach is divided into two species, (a) *Amaranthus hybridus caudatus L.* which has long leaf with a pointed tip, reddish green or dark red leaf, it has a long flower in the tip of stem; (b) *Amaranthus hybridus paniculatus L.* has a very wide leaf with green colour and long flower in the armpit leaves.

Spinach is promoted as a vegetable, a source of nutrition for the population in developing countries. Spinach contains carbohydrates, fat, protein, calcium, phosphorus, iron, vitamin A, vitamin B1, vitamin C, and water so that all levels of society favour it. Spinach leaves can be made of various types of food such as soup, gado-gado, pecel and even served as a luxury dish. In some developing countries, spinach is promoted as a source of vegetable protein because it has doubles function in the fulfilment of nutritional needs and public health services. Other benefits are as traditional medicine ingredients, and for beauty. Red spinach root can be used as a cure for dysentery. The leaves and flowers of spiny spinach are useful for treating asthma and eczema. Even to a certain extent, spinach can overcome various types of internal diseases. For external medicine, spinach can be utilised as a cosmetic ingredient (beauty). Spinach seeds are used for food and medicine. The usage of Spinach seeds is for a mixture of wheat flour in bread making or spinach seed porridge. Spinach seed extract is efficient as medicine for vaginal discharge and bleeding excessive in women menstruating. Omosun (2008) said that spinach has various uses, generally as a source of vitamin A. Besides that, it also use in the treatment of intestinal bleeding, excessive diarrhoea and menstruation.

There are many benefits of spinach for human health, because of that need an effort to increase the number of spinach axillary buds. Because this axillary bud will grow became a branch. The more axillary buds grow, the more branches are formed. The more branches that are formed, the more the number of spinach leaves that can be consumed. One effort to increase the number of axillary buds is apical buds pruning. The application of apical buds pruning techniques has been done in the world of agriculture. In vines, pruning is aim to increase fruit production. Young branches that grow from the main stem trimmed so in the next season will growl new fruit-producing branch. In tea plants, to get the maximum bud results, pruning needs to be done periodically if the plant has reached a height of more than 110 cm. In tobacco plants, pruning is arranged so that each stem has as many leaves as possible. Pruning of apical buds on several levels of soybean plants has a significant influence on the growth variable, which has a significant effect on plant height, number of primary branches, number of plant segments, number of fertile segments (Esrita, 2012).

Apical buds pruning will stimulate more axillary bud growth. Proper pruning can increase 35% higher than plants that are not pruned. Apical buds pruning in plants will trigger the growth of axillary buds that subsequently grow into plant branches. In these branches, the new bud will appear. If the branches that are formed are getting longer, it is assumed that there are more growing buds. This will make pruned plants to have a number of buds (primary axillary buds and secondary axillary buds). The higher number and length of buds will cause the plant has a greater number of leaves, it means that the producing of assimilates is greater (Irawati, 2006).

Apical bud inhibits axillary bud growth; this phenomenon called apical dominance. Pruning of apical buds stimulates dormant axillary buds to grow (Mu'ller, 2011). It is known that the hormone auxin causes apical dominance. Auxin synthesis occurs in parts of plants that are growing or in the meristematic part, especially in apical buds. Auxin that is synthesized in these apical buds that transported naturally to the lower part of the stem. This causes the accumulation of auxin in the armpit leaves, which will inhibit the initiation of axillary bud formation in armpit leaves or will cause dormancy because the initiation of axillary bud formation requires a lower concentration of auxin than the optimal concentration of auxin for stem length growth.

The presence of auxin affects the axillary buds. Decapitation treatment (reduction of auxin concentration) in *P. sativum* can increase the concentration of cytokines in the main stem and axillary buds. The Increasing of cytokine concentration occurs in the main stem followed by the increasing of cytokines concentration in axillary buds. This shows that the decreasing of auxin concentration through decapitation can increase concentration of cytokine transport by acropetal from the root to the main stem, then it is transported to axillary buds. Auxin transport is based on the theory, which states that axillary bud growth that regulated by auxin transport from the tip of the stem to the main stem by bicipital. Based on this theory, the transport of auxin from the axillary bud to the main stem is necessary to initiate the growth of buds. In plants that have strong apical dominance, it is suspected that the transport of auxin from the apical to the main stem is large so the auxin in the lateral buds unable to be transported to the main stem that will inhibit axillary bud growth (Dun, 2006).

Equilibration between the ratio of auxin and cytokine is needed for bud growth. The role of auxin and cytokinin in growth is shown by Nagarathna (2010) in a study of Helianthus annuus. At the beginning of the study, measurements of the concentration of auxin and cytokine were carried out on all axillary nodes to determine the translocation of each of these hormones. Based on the results of the study, the concentration of auxin will decrease in the axillary nodes that are far from the tip, whereas the concentration of cytokines increases in the axillary nodes that are far from the tip. Nagarathna does decapitate in the apical buds of H. annuus. The results showed that the lower axillary nodes showed growth rapidly than the other axillary nodes on it because of the low auxin concentration and high cytokines concentration in the lower axillary nodes. It shows that equilibration between the auxin and cytokines is necessary to accelerate bud growth.

The learning outcomes of horticulture courses in the biology programme at IKIP Saraswati are (1) students can comprehend the basic knowledge of horticulture; (2) students can apply the basic knowledge of horticulture in horticultural farming and making gardens and; (3) students can use concepts, principles and procedures in horticulture studies to discover, analyze, and solve problems with the application of science and technology. To achieve these learning outcomes, stu-

dents are expected to have several abilities. One of the expected abilities is students are able to identify important factors that influence the horticulture business. Students that are actively involved in the learning process can possess this ability. In active learning, students are no longer placed in a passive position as recipients of teaching materials that given by the teacher/lecturer, but students as active subject to carry out the process of thinking, searching, processing, analyse, merging, concluding, and solving problems (Hanafiah, 2009).

One of the problems that confront in the education is that the weakness of learning process, students are not encouraged to develop their thinking skills, while teachers still apply traditional teaching methods, which are oriented towards students' cognitive measurement. While in the constructivism paradigm. Learning must be able to measure three aspects that are cognitive, affective, and psychomotor. To achieve these three aspects, learning activities in the classroom are not enough only apply the “talk” method, because the teacher only provides material theoretically, and students are not actively involved in learning even students cannot use the material directly by observations or experiments.

According to constructivism paradigm, learning that is applied has to be oriented to the development of students' knowledge independently. Students are training to discover information on independent learning and create cognitive structures actively in interaction with their environment so that student-centred learning is realised. One good learning strategy and accordance to the constructivism is the application of experiment-based learning model. In experiment-based learning students are directed to experimental learning (learning based on concrete experience), discussions with friends, so that will be obtained new ideas and concepts. Therefore, learning is seen as a process of knowledge organisation from concrete experience, collaborative activities, reflection and interpretation (Hayat, 2011).

Experimental learning is appropriate to science learning because it is able to provide learning conditions that develop thinking skills and creativity optimally. Students are given the opportunity to construct their concepts in their cognitive structure; then they can be applied it in their lives. The aim of this experimental method is students are able to discover various answers or problems by conducting their experiments. In addition, students can be trained in scientific thinking, with experiments students find evidence of the truth and the theory of something that is being studied (Mulyani, 2015).

Based on the explanation, the aims in this study is to discover (1) whether apical bud pruning affects the growth of aksilar bud; (2) whether this experiment model can be implemented in the process of horticulture courses?

METHOD:

This type of study is experimental research using Fully Randomized Design. The population in this study consists of 14-day-old spinach that placed in the seedbed, which was seedling from prepared seeds. The using spinach taken randomly from the seedbed and then planted in the experimental pots. Each pot was planted with one spinach. After the spinach was 21-days-old, the samples were grouped into five groups. The first group as a control group was not cut, the second, third, fourth and fifth groups were cut off in the each apical with 3 cm, 6 cm, 9 cm and 12 cm of length. The repetition is carried out four times.

The data obtained about the number of axillary buds is calculated by using a normality test and homogeneity test. The normality test carried out through the *Kolmogorov-Smirnov* and *Shapiro-Wilk*. While the homogeneity test was carried out by the *Levene* test. The significance level (α) is set at 0.05. The normality and homogeneity test criteria that were used are significance numbers (sig.) was greater than the significance level (α), the statistically significant numbers are not significant, it was indicated that the sample data was obtained from populations with normally distributed and in reverse. If the requirements for normality and homogeneity already fulfilled, then the parametric analysis continue with ANOVA test. If there were significant differences, it was necessary to do advanced testing to find out which groups are different. Advanced testing is carried out by LSD test or BNT test.

RESULT AND DISCUSSION

RESULT:

After seven days in the apical bud pruning, the calculation was done on the number of axillary buds in each sample. Calculation on the number of axillary buds is conducted until 41-days-old spinach. The complete data on the number of lateral buds in each treatment is on Table 1.

Table 1. Data one number of axillary buds in each treatment

Repetition (N)	TREATMENT				
	J0 (Control)	J1 (3 cm on pruning)	J2 (6 cm on pruning)	J3 (9 cm on pruning)	J4 (12 cm on pruning)
I	32	58	53	52	47
II	39	60	48	55	51
III	51	74	59	48	35
IV	41	72	40	53	45
Total	163	264	200	208	178
Average	40.75	66	50	52	44.5

Based on the data in table 1 can be described the number of axillary buds in each treatments shown in figure 1.

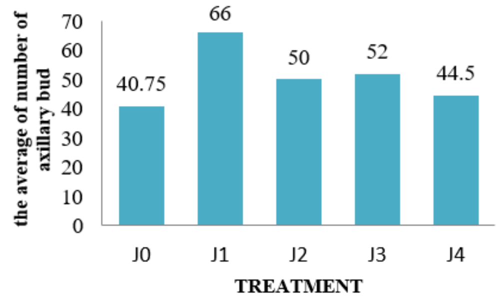

Figure 1. Graphic of the average on the number of axillary buds in each Normality test and homogeneity test.

The testing of normality data is through Shapiro-Wilk, whereas homogeneity of data was verified by Leven. The result of analysis both data' normality and data' homogeneity is showed in Table 2 and Table 3.

Table 2. The result of Normality Test using *Shapiro-Wilk*

	Shapiro-Wilk		
	Statistic	Df	Sig.
J0	0.971	4	0.845
J1	0.844	4	0.207
J2	0.994	4	0.979
J3	0.953	4	0.734
J4	0.923	4	0.556

Based on the result of the normality test using Shapiro-Wilk on table 2 can be showed that the entire outcome of testing indicate sig. is greater than 0.05. It is mean that the whole data have a normal distribution.

Table 3. The result of Homogeneity test using *Levene*

Levene Statistic	df1	df2	Sig.
1.132	4	15	0.379

Based on Table 3 can be seen that sig. Value is 0.379, it showed that the value was higher than the significant level that has been determined, that was 0.05. It means that the data variance in this study was homogenous. Because of that, the ANOVA test can be continued. The summary of the entire test is on Table 4.

Table 4. Anova Test

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	1494.8	4	373.7	7.537	0.002
Within Groups	743.75	15	49.583		
Total	2238.55	19			

Based on the result of ANOVA Test on Table 4, can be shown that F value was 7.537 with the sig. value was 0.002 that was smaller than the predetermined significant value (0.05). It means that generally there was significant difference between the numbers of axillary bud in each treatment. Because of that significant difference, then it needs advance test using LSD test or BNT test. Table 5 shows the result of those advance tests.

Table 5. LSD Test

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
J0	J1	-25.250*	4.979	0	-35.86	-14.64
	J2	-9.25	4.979	0.083	-19.86	1.36
	J3	-11.250*	4.979	0.039	-21.86	-0.64
	J4	-3.75	4.979	0.463	-14.36	6.86
J1	J0	25.250*	4.979	0	14.64	35.86
	J2	16.000*	4.979	0.006	5.39	26.61
	J3	14.000*	4.979	0.013	3.39	24.61
	J4	21.500*	4.979	0.001	10.89	32.11

(I) Treatment	(J) Treatment	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
J2	J0	9.25	4.979	0.083	-1.36	19.86
	J1	-16.000*	4.979	0.006	-26.61	-5.39
	J3	-2	4.979	0.694	-12.61	8.61
	J3	5.5	4.979	0.287	-5.11	16.11
J3	J0	11.250*	4.979	0.039	0.64	21.86
	J1	-14.000*	4.979	0.013	-24.61	-3.39
	J2	2	4.979	0.694	-8.61	12.61
	J4	7.5	4.979	0.153	-3.11	18.11
J4	J0	3.75	4.979	0.463	-6.86	14.36
	J1	-21.500*	4.979	0.001	-32.11	-10.89
	J2	-5.5	4.979	0.287	-16.11	5.11
	J3	-7.5	4.979	0.153	-18.11	3.11

*. The mean difference is significant at the 0.05 level.

Based on the advanced test, can be discovered that there were five pair treatments which are shown the significant difference in result. Five pairs treatment was indicated by yellow colour in Table 5, that were: J1-J0, J1-J2, J1-J3, J1-J4, and J0-J3. The most significant seen in J0 as a control group with J1 as a group with 3 cm on axillary bud pruning. The result indicates that in J1 produce the most number of axillary bud with 66 on average.

DISCUSSION:

Based on the results of the ANOVA test in Table 4, it could be seen that the F value is 7.537 with sig. was 0.002 which is smaller than the predetermined significance level of 0.05. This means that in general there was a significant difference between the number of axillary buds of spinach based on each treatment. The number of axillary buds in spinach that was pruned on its apical buds was greater than that which is not apical bud-pruned. This happened because auxin synthesis occurred in growing part of the plant or in the meristematic part, especially in the apical buds. Auxin synthesised in these apical buds will be transported naturally to the lower portion of the stem. This causes the accumulation of auxin in the armpit leaves which lead the inhibition of axillary bud formation in armpit leaves or dormancy. The pruning of apical buds causes the absence of hormone production in apical buds. As a result, auxin which has flowed naturally could not take place. Auxin which has been accumulated in axillary buds will be transported to the main stem. The presence of auxin transport from axillary buds to the main stem caused the amount of auxin in axillary buds decreases. This decreasing number of auxin in axillary buds would stimulate the growth of axillary buds. This is appropriate with Mu'ller (2011) said that pruning of apical buds stimulates dormant axillary buds to grow. Apical bud pruning on the plant will trigger the growth of axillary buds which subsequently grow into plant branches. In these branches will grow new buds which allow pruned plants have more buds (primary and secondary axillary buds).

Based on the results of advanced tests, it can be seen that there were five pairs of treatment that showed significant difference results. The pairs indicate by yellow colour in table 5, namely: J1-J0, J1-J2, J1-J3, J1-J4, and J0-J3. The most significant difference was seen between groups J0-l (no pruning of the buds) with group J1 (pruned by the 3 cm length on bud). This means that group J1 gave the highest number of lateral buds with an average of 66. At the pruning of apical buds as long as 3 cm (J1) the number of axillary buds was the most, because the presence of axillary buds affects by the presence of auxin and cytokine. Nagarathna (2010) shows the role of auxin and cytokines in growth within the study of *Helianthus annuus*. At the beginning of the study, measurement of the auxin concentration and cytokine concentration were carried out on all axillary nodes to determine the translocation of each both hormones.

Based on the results of the study, the concentration of auxin will decrease in the axillary nodes that were far from the tip, whereas the concentration of cytokines increases in the axillary nodes that were far from the tip. Nagarathna decapitates the apical buds of *H. annuus*. The results showed that the lower axillary nodes showed rapid growth than the other axillary nodes above because of the low concentration of auxin and high concentration of cytokine in the lower axillary nodes. This showed that there would be needs of equilibrium between the ratio of auxin and cytokine to stimulate bud growth. Decapitation treatment (reduction of auxin concentration) in *P. sativum* could increase the concentration of cytokines in the main stem and axillary buds. The Increasing of cytokine concentration occurs in the main stem, and it was followed by the increase of cytokinin concentration in axillary buds. The equilibrium between the ratio of auxin and cytokinin is needed for bud growth. Referring to the results of the study on *P. sativum* and *H. annuus*, the optimal equilibrium of the ratio of auxin and cytokinin was possible to the apical bud pruning on 3cm of length (J1) so that the number of axillary buds grew the most. It was because of cytokinins function to stimulate cell division in meristematic tissue, stimulate the resulting differentiation in meristematic tissue, and encourage the growth of axillary buds and leaf expansion.

One of the problems in our education was the weakness the learning process, students were not encouraged to develop their thinking skills, while teachers still apply traditional teaching methods, which were oriented towards students' cognitive measurement. While in the learning constructivism paradigm, the learning process must be able to measure three aspects that were cognitive, affective, and psychomotor. To achieve these three aspects, classroom learning activities are not enough to apply the "talk" method, because the teacher only provides material theoretically, and students are not actively involved in learning, even students cannot apply the material directly in by observations or experiments. This principle causes a paradigm shift in the education process, from the teaching paradigm to the learning paradigm. The teaching paradigm that focuses more on the role of educators in transforming knowledge to their students changed to the learning paradigm, which gives more roles to students to develop their potential and creativity (Oka, 2016).

The development of potential and creativity of students could be obtained through Observing, Questioning, Associating, Experimenting and Networking. Because of that the teacher/lecturer have to design a learning process that prioritizes personal experience through the process of observing, asking, reasoning and trying (observation based learning) to improve the creativity of students. In addition, students have to work in networking through collaborative learning (Minister of Education and Culture, 2013). The experiment was a critical part of a learning activity, especially to realize the learning outcomes of horticulture subjects, that was students were able to apply the basic knowledge of horticulture in cultivating horticultural plants and making gardens. Because experiments in horticultural learning can improve the ability to organise, communicate, and interpret the results of observations. The experiment could: (1) motivate students to develop curiosity; (2) teach the skills that must be done when conducting experiments; (3) assisting the acquisition and development of basic biological concepts; (4) encourage scientific attitudes, (5) encouraging the development of social skills.

One good learning strategy that was appropriate with constructivism paradigm was experimental learning (learning based on concrete experience), discussion with friends, which would be obtained new ideas and concepts. Therefore, learning was seen as a process to organise knowledge from practical experience, collaborative activities, and reflection and interpretation. Experiments could provide opportunities for students to develop skills and willingness to think logically. Through experiments, students were stimulated to be active in solving problems, thinking critically in analyzing the problems and facts that exist, and discover concepts and principles. Therefore, the creation of meaningful learning with a conducive learning atmosphere is exist.

Based on the description was explained clearly that the implementation of experiments about the effect of apical bud pruning on axillary bud growth was an integral part of teaching and learning activities, especially in the horticultural course. By experiment, activity will (1) clarify the concepts that were presented in the class through direct examples; (2) improve students' intellectual skills through observation or discover theory information completely and selectively that support the mapping of problem experiments, training in problem solving, applying knowledge and skills to the situation; (3) training in experiment design, interpreting data and fostering scientific attitudes.

CONCLUSION:

There was a significant difference between the number of axillary buds in spinach, which did not prune the buds (J0) with the apical bud pruning of 3cm in length (J1), 6cm in length (J2), 9cm in length (J3) and 12cm in length (J4). The most significant difference was seen between pairs of groups J0 (not pruned the apical bud) with group J1 (apical bud pruning in 3 cm of length). Group J1 gave the highest number of axillary buds with 66 on average.

By implementing apical buds pruning experiment to increase the growth of axillary buds of Tahun spinach (*amarantus hybridus L.*) horticultural course, then pre-service teacher students will be trained on how to design an experiment, make observations, data collecting, data analyzing. This experiment will lead students to be active in problems solving, thinking critically in analyzing the existing problems and facts, and discover concepts and principles until the learning activities were more meaningful with a conducive learning atmosphere.

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